MAGSAT PROGRAM

Progress Report No. 2

Investigation Number M-41

THE REDUCTION, VERIFICATION AND INTERPRETATION OF MAGSAT MAGNETIC DATA OVER CANADA

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I. INTRODUCTION

This investigation is primarily concerned with studies of the magnetic field originating in the solid earth, as measured by Magsat. Most of this field originates in the core, but an important part is of lithospheric origin. Magnetic anomalies of lithospheric origin are weak at Magsat altitudes (20 to 30 nT at most), and they can be easily masked by much larger effects caused by field-aligned and other currents at high latitudes. Most of Canada lies under the influence of ionospheric currents in the auroral zone and polar cap.

Procedures have now been established to select quiet, least-disturbed Magsat data. A preliminary map of scalar field anomalies over Canada and adjacent regions has been produced.

II TECHNIQUES

The basic selection techniques have been described in Progress Report No. 1. (November 1980). The actual criteria have been made rather more stringent, and the data from Fort Churchill magnetic observatory (an auroral zone station) have been used in classifying Magsat passes as quiet, unsettled, or disturbed - A, B, or C. The mid-latitude and polar cap conditions are normally no worse than the auroral zone conditions.

An additional parameter is now taken into consideration. Determinations of long-term quiet levels at Canadian magnetic observatories are being made by J.K. Walker. For the time interval of each Magsat pass, we determine the deviations of the mean hourly values of the magnetic field components from these quiet levels, in particular for Fort Churchill. These deviations provide an additional constraint on the acceptability of the pass.

We have now passed through our primary processing all CHRONINT tapes received to date, that is, all Magsat data except for that in 3 isolated weeks. This processing decodes orbit records, decimates data records, selects time intervals and latitude intervals, and produces output tapes carrying records with data point time, position and magnetic information.

Subsequent processing converts the coordinate system from geocentric to geodetic and removes a reference field (at this time we are still using MGST 3/80, until a satisfactory model with time terms is available). This stage of processing is complete for data up to the end of May 1980, that is, about 90% of all the CHRONINT data.

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Secondary selection, based on the magnetic activity at Fort Churchill, is then applied, followed by detailed visual inspections and comparisons of plots of selected passes.

At this stage, we are concerned only with the scalar field derived from the fluxgate magnetometer ($F^2 = X^2 + Y^2 + Z^2$), since the scalar magnetometer was unreliable, and since the intermediate attitude vector data contain serious biasses. A quadratic function is fitted by least squares to the computed scalar residuals in each Magsat pass. This function is then subtracted from the data. These quadratic functions, at this stage, serve to remove residual external field effects and also secular variation effects.

The selected, adjusted Magsat data have been gridded and a mean data value derived for each grid cell in the Canadian map area. No explicit adjustments have been made for altitude variations within and between grid cells at this stage.

III ACCOMPLISHMENTS

The preliminary map resulting from the processing of selected data up to March 30, 1980, that is, 166 passes, is shown in Fig. 1. It must be emphasized that this map is very preliminary. Certain features in central and eastern parts of the map result from the lack of data and peculiarities of the automatic contouring.

However, the coverage of passes is very good in the western and northern parts of the map. Striking anomalies occur over the Alpha Ridge in the Arctic Ocean, north Greenland, and Alaska/Yukon. These and other features are in good agreement with those seen in maps from POGO data and airborne data.

In the eastern part of the Magsat map, coverage is not as good. Fewer passes are acceptably quiet, in part as a result of the time of day and the influence of auroral activity. However, some discernible features tend to agree with earlier maps. It is hoped that processing of remaining data will fill the gaps in this part of the map.

Detailed pass-by-pass examinations over the longitude range 20°E to 160°E, i.e. the eastern Eurasian sector of the transpolar region, have not been made. However, on the basis of acceptability over Canada, the same set of 166 passes was used to produce the preliminary map shown in Fig. 2, covering the whole region north of about latitude 40°N. The general agreement with the POGO data north of 50°N is excellent.

A preliminary comparison of the 'computed scalar' Magsat data with our Canadian high-level airborne magnetic data set has been made. The airborne data were updated to epoch 1980.0, using secular variation trends. Both airborne and Magsat data sets have been reduced to sea-level, using field models. The Magsat total scalar field data are in excellent agreement with the airborne data. This is encouraging from the standpoint of producing regional magnetic charts.

IV SIGNIFICANT RESULTS

Other than to refer to the map and comparisons with other data, discussed above, it is too early to comment on significant results.

V PUBLICATIONS

None in this time period.

Two oral papers are planned for the IAGA Symposium in Edinburgh, August 1981. Abstracts have been submitted.

1. Preliminary maps of magnetic anomalies o r Canada from MAGSAT data, by Coles, Haines, Nandi, Jansen van Beek, Walker

2. A total force chart of Canada for 1980 derived from Magsat data, by Newitt, Dawson, Coles, Nandi.

VI & VII PROBLEMS AND DATA DELIVERY

Only one Investigator tape (other than test tapes) has been received to date, covering data in November 1979. Consequently, in order to proceed to the stage we are now at, we have processed more CHRONINT tapes than originally intended. We have only just received the first production shipment of CHRONFIN tapes, covering the full month of November 1979. Thus, we have not yet been able to analyze any fine-attitude vector data.

We do not intend to process fine-attitude data from known disturbed passes. Early receipt of more Investigator tapes would be appreciated.

VIII RECOMMENDATIONS

Nothing further at this time.

IX CONCLUSIONS

Early results have been very encouraging.

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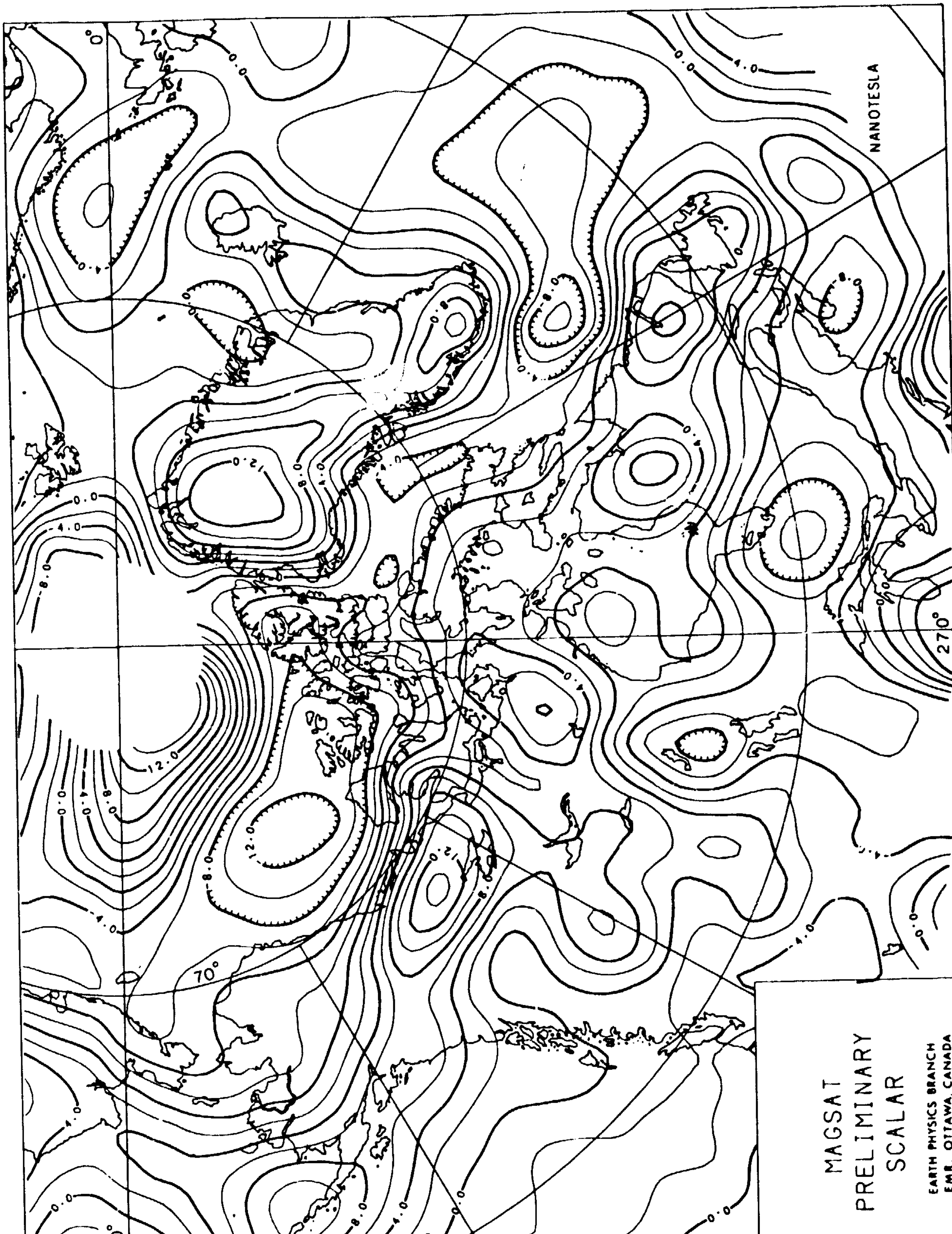

FIG. 1

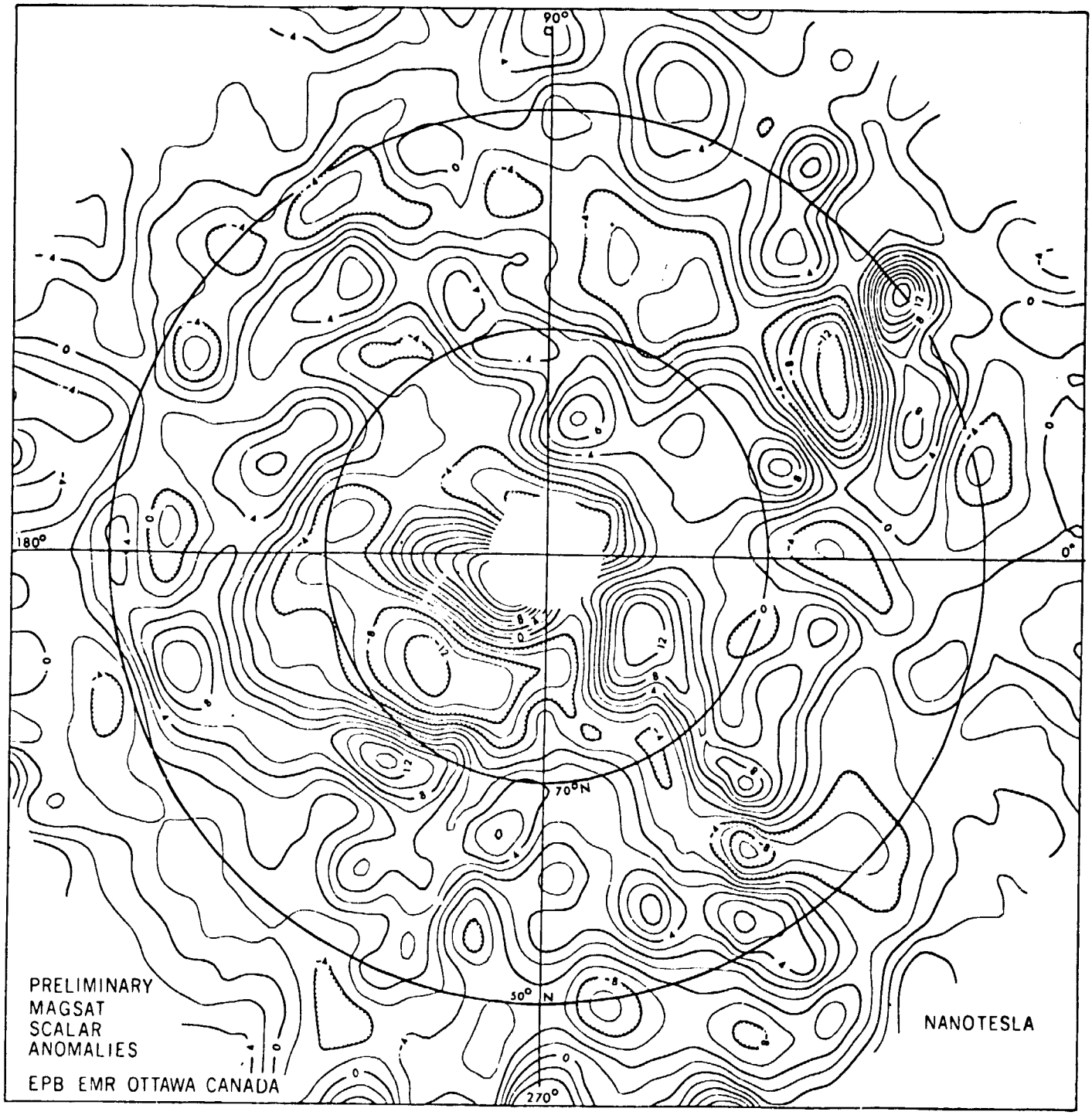

FIG. 2

PRELIMINARY MAPS OF MAGNETIC ANOMALIES OVER CANADA FROM MAGSAT DATA

R.L. Coles, G.V. Haines, A. Nandi, G. Jansen van Beek, J.K. Walker (Earth Physics Branch, Department of Energy, Mines and Resources, Ottawa, Canada K1A 0Y3)

Preliminary maps of magnetic anomalies over Canada and environs have been derived from MAGSAT data acquired at altitudes between 320 and 500 km. Only data obtained during magnetically quiet intervals have been used. Acceptance criteria were low Kp indices, low short-term ranges and low deviations from long-term quiet levels at auroral zone magnetic observatories, and subsequent visual inspections and comparisons of plots of the selected passes. A preliminary NASA reference field of degree and order 13, without time terms, has been removed. Corrections for residual external field effects and secular variation have been made by removing from each pass a quadratic function fitted by least squares to the data in that pass. No specific adjustments for altitude variations have been made in these preliminary maps.

The scalar anomaly map shows, with greater definition, features seen in maps from the POGO satellite data and from upward-continued airborne magnetometer data. The map is particularly good over western Canada and Arctic regions. The coverage of quiet MAGSAT passes is less complete in the east; passes there tend to be rather more disturbed.

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5. Oral presentation only.

A TOTAL FORCE CHART OF CANADA FOR 1980 DERIVED FROM MAGSAT DATA

L.R. Newitt, E. Dawson, R.L. Coles, A. Nandi (Earth Physics Branch, Department of Energy Mines and Resources, Ottawa, Canada, K1A 0Y3)

To evaluate the use of Magsat data for the production of regional magnetic charts, a comparison was made between a total force chart derived from preliminary Magsat F data with one derived from Canadian aeromagnetic data. The satellite data, acquired for magnetically quiet intervals only, at altitudes between 320 and 500 km, were reduced to sea level using the spherical harmonic model MGST(3/80-2). The aeromagnetic data for the period 1959 to 1976 at an average altitude of 2-3 km, were reduced to sea level using the simple relation $4.6^3 \times 10^{-7} \times F \times$ altitude (in metres). These data were updated to 1980. Both the satellite and airborne data were gridded at 1° intervals of latitude and longitude, and the F -charts derived from these gridded values.

There is very close agreement between the two charts, with no obvious biases. The main differences occur only in regions with sparse coverage. The mean difference between the satellite and aeromagnetic grid values is 26nT, with an RMS difference of 118nT.

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(a) Oral Presentation